



GRUPE SARCOME FRANÇAIS
*Les journées
annuelles*

14^{es} journées annuelles du GSF-GETO

20, 21 & 22 juin 2018

LE CORUM, PALAIS DES CONGRÈS, MONTPELLIER, FRANCE



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Quoi de neuf en imagerie

Mariem BEN HAJ AMOR, Centre Oscar Lambret, Lille

Amandine CROMBE, Institut Bergonié, Bordeaux

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Centre Régional de Lutte
contre le Cancer

Bergonié
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NOUVELLE-AQUITAINE



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Quoi de neuf en imagerie

SESSIONS PARALLÈLES « GROUPES DE TRAVAIL » ÉTAT D'AVANCEMENT DES TRAVAUX ET NOUVEAUX PROJETS

- **Oncologie médicale / Pédiatrie** (N. Firmin, F. Duffaud, N. Gaspar & N. Corradini)
- **Biologie / Anatomie pathologique** (M-C. Château, C. Bouvier-Labit, L. Linares)
- **Épidémiologie / Santé publique / Économie** (S. Mathoulin-Pélissier & S. Gourgou)
- **Imagerie / Radio interventionnelle / Médecine nucléaire** (M. Kind & R. Tetreau)
- **Chirurgie viscérale tissus mous** (S. Carrere & S. Bonvalot)
- **Orthopédie** (B. Megy, C. Lazerges, F. Gouin)
- **Radiothérapie** (C. Llacer, P. Sargos, M.P. Sunyach)

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Oscar Lambret
Centre Régional de Lutte
contre le Cancer

Bergonié
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NOUVELLE-AQUITAINE

Actualité en imagerie

▶ PARTIE 1: Actualité en imagerie des tumeurs osseuses

- Tumeurs à cellules Géantes et Dénosumab
- IRM de perfusion / Sarcome

▶ PARTIE 2: Actualité en imagerie des sarcomes des tissus mous

- IRM corps entier: diagnostic précoce de la rechute métastatique des M/RC-LPS
- PET-IRM pour la détection des rechutes locales

▶ PARTIE 3: Radiomique

- Principe
- Optimisation d'un modèle prédictif de la rechute métastatique pulmonaire des STM
- Caractérisation des tumeurs cartilagineuses

Giant Cell Tumors of the Bone: Changes in Image Features after Denosumab Administration

Sota Oguro^{1*}, Shigeo Okuda¹, Hiroaki Sugiura¹, Shunsuke Matsumoto¹,
Aya Sasaki², Michiro Susa³, Hideo Morioka⁴, and Masahiro Jinzaki¹

RATIONNEL

TCG osseuse / CT: reminéralisation

IRM? Evaluation du changement morphologique / IRM des Tumeurs à Cellules Géantes osseuse sous denosumab

Giant Cell Tumors of the Bone: Changes in Image Features after Denosumab Administration

Sota Oguro^{1*}, Shigeo Okuda¹, Hiroaki Sugiura¹, Shunsuke Matsumoto¹,
Aya Sasaki², Michiro Susa³, Hideo Morioka⁴, and Masahiro Jinzaki¹

METHODOLOGIE

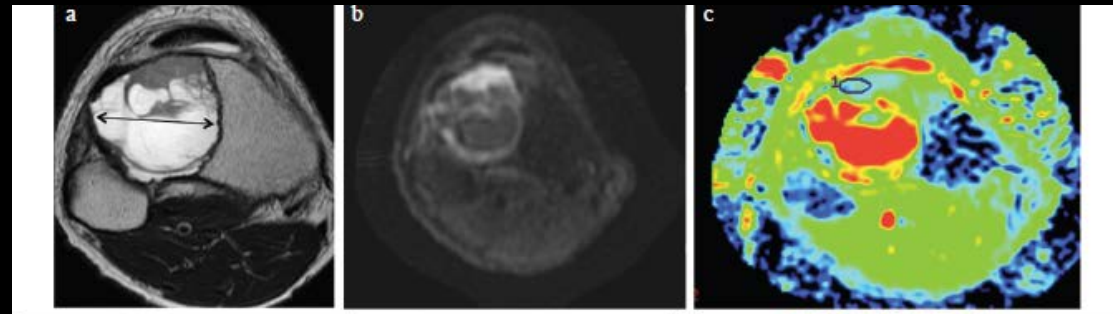
Etude monocentrique rétrospective (2011-2014) : **12** patients [6 chirurgie au préalable],

IRM pré et post traitement (**18 mois**):

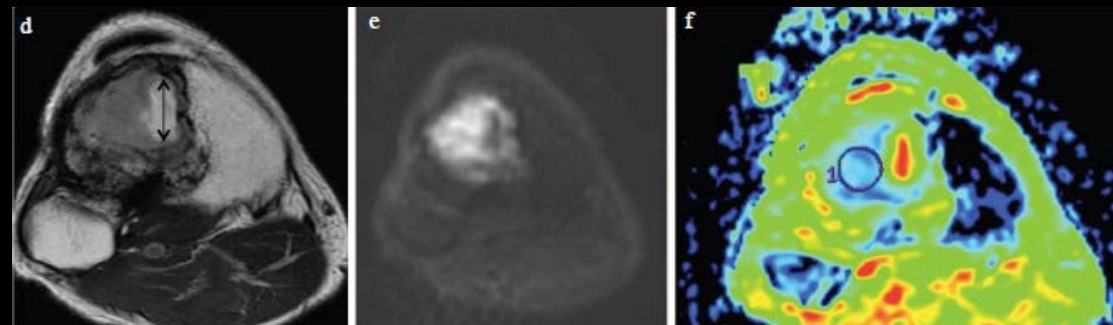
- Taille T2 axial
- (SI) : ratio signal composante tissulaire et le muscle adjacent en T2 (tumor SI/muscle SI)
- Taille T2 composante Hsignal
- Cartographie ADC

RX/CT

Pré TTT



Post TTT



Giant Cell Tumors of the Bone: Changes in Image Features after Denosumab Administration

Sota Oguro^{1*}, Shigeo Okuda¹, Hiroaki Sugiura¹, Shunsuke Matsumoto¹, Aya Sasaki², Michiro Susa³, Hideo Morioka⁴, and Masahiro Jinzaki¹

RESULTS

No.	Sex	Age	Location	Pretreatment	Tumor size (mm)		Size of cystic component (mm)		SI ratio on T ₂ weighted image		New bone formation	ADC value (10 ⁻³ × mm ² /sec)	
					Pre	Post	Pre	Post	Pre	Post		Pre	Post
1	M	37	Tibia	-	60	50	43	18	3.6	2.9	+	1.03	0.66
2	M	26	Humerus	-	66	55	39	15	9.7	3.6	+	1.55	1.33
3	M	33	Carpus	-	25	22	10	0	4.9	1.1	+	1.25	1.29
4	M	52	Vertebra	-	32	30	15	15	10.7	0.9	+	1.66	2.24
5	M	41	Skull bone	-	46	20	40	12	3.5	2.7	-	2.60	1.74
6	F	34	Vertebra	-	23	22	0	0	2.2	1.7	+	0.91	1.23
7	M	54	Radius	Curettage with bone grafting	25	24	0	0	1.2	1.1	+	N/A	N/A
8	M	34	Femur	Curettage with bone grafting	64	60	0	0	1.3	0.8	+	N/A	N/A
9	F	26	Vertebra	Curettage alone	89	87	0	0	2.4	1.6	-	N/A	N/A
10	F	51	Vertebra	Curettage alone	30	24	0	0	2.2	1.3	-	N/A	N/A
11	F	39	Vertebra	Curettage alone	31	30	0	0	2.2	1.7	-	N/A	N/A
12	F	66	Sacrum	Embolization	74	63	0	0	3.4	3	-	N/A	N/A

P=0.01

P=0.02

P=0.036

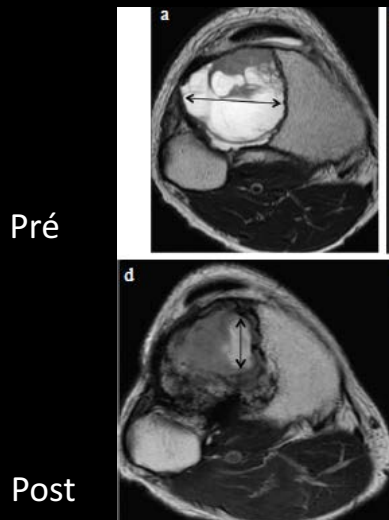
7

P=0.70

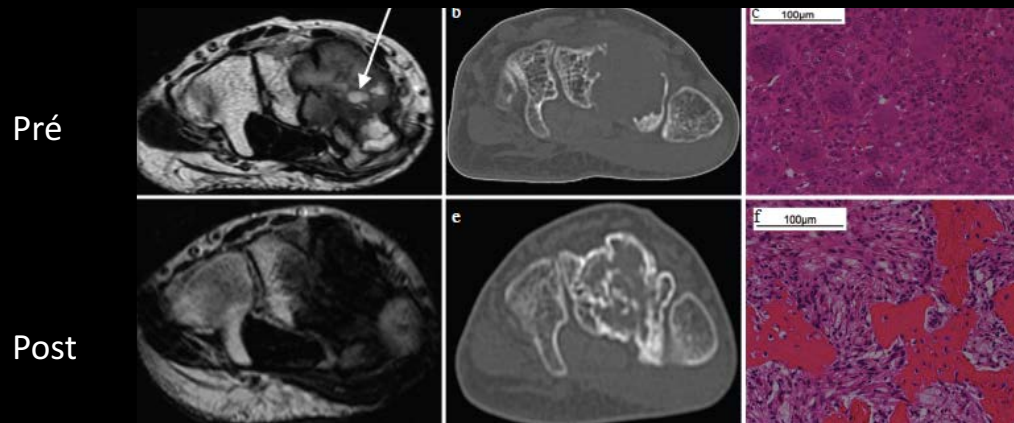
revealed. All tumors were demonstrated in homogeneous hypointensity on FsT₁WI before the treatment. Marked enhancement was observed at the solid part of the tumor both pre- and post-treatment in seven patients. In one patient, the marked enhancement was changed to mild one due to strong calcification after the treatment. In three patients, the tumors were mildly enhanced before and after the treatments. The

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- Diminution taille en T2
- Diminution de la composante Hsignal
- Diminution ratio (SI)



Reminéralisation sauf squelette axial et TTT chirurgical préalable

➔ Intérêt de l'IRM chez ces patients

Perfusion MR imaging at 3-Tesla: Can it predict tumor grade and histologic necrosis rate of musculoskeletal sarcoma?

P.A. Gondim Teixeira^{a,*}, A. Renaud^b, S. Aubert^c,
M. Ben Haj Amor^b, Y.-M. Robin^d, A. Cotten^e,
L. Ceugnart^b

Diagnostic and Interventional Imaging (2018) <https://doi.org/10.1016/j.diii.2018.02.005>

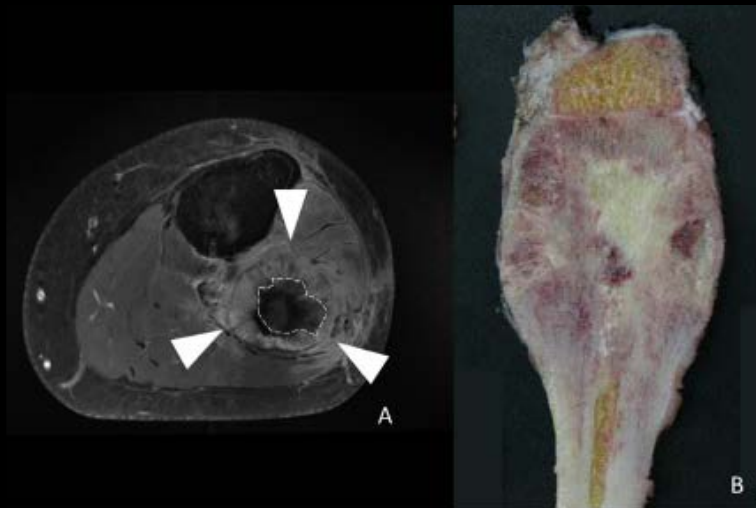
RATIONNEL:

Identifier les paramètres quantitatifs de perfusion-IRM qui sont corrélés au grade / nécrose tumoral histologique

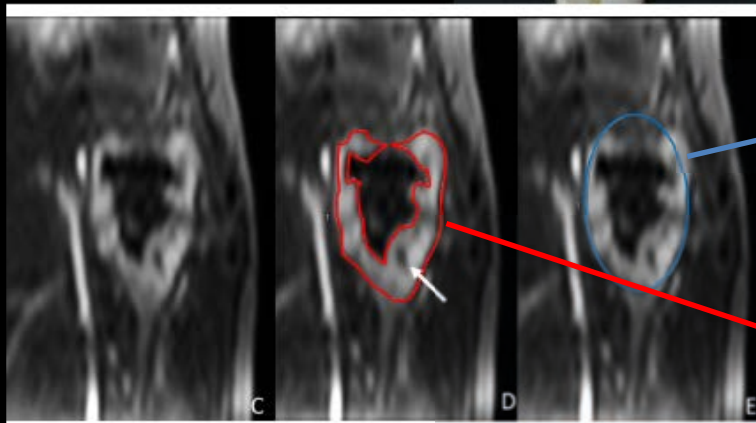
Perfusion MR imaging at 3-Tesla: Can it predict tumor grade and histologic necrosis rate of musculoskeletal sarcoma?

METHODOLOGIE

Etude monocentrique rétrospective (2014-2017) : 31 patients [6-86 ans],
IRM 3T, min 3 mois avant chirurgie
18 CT, 4 RT, 9 (-)
18 T.Os/ 13 STM



[grade- différenciation- index de nécrose- index mitose]



Tumeur globale

% nécrose tumorale (INI)

Partie tissulaire

Perfusion MR imaging at 3-Tesla: Can it predict tumor grade and histologic necrosis rate of musculoskeletal sarcoma?

METHODOLOGIE

Paramètres semi-quantitatifs :

Aire sous la courbe

AUC

Hauteur de pic/baseline

CER

Pente initiale

Max slope

Paramètres de perméabilité (T1 900 ms):

Constante de perméabilité

K_{ep}

Constante de transfert

K^{trans}

Volume extravasculaire-extracellulaire

V_e

Perfusion MR imaging at 3-Tesla: Can it predict tumor grade and histologic necrosis rate of musculoskeletal sarcoma?

RESULTATS

Patient	histologie	GRADE (FNLCC/Broder's)	Nécrose
1	Leiomyosarcoma	2	1
2	Metastatic osteosarcoma	3	2
3	Liposarcoma	3	1
4	Leiomyosarcoma	3	2
5	Myxofibrosarcoma	3	1
6	Spindle cell sarcoma	3	2
7	Osteosarcoma	3	2
8	Osteosarcoma	3	2
9	Synovial sarcoma	2	2
10	Ewing's sarcoma	3	1
11	Ewing's sarcoma	3	0
12	Myxofibrosarcoma	1	0
13	Spindle cell sarcoma	2	0
14	Osteosarcoma	3	2
15	Ewing's sarcoma	3	1
16	Dedifferentiated liposarcoma	3	2
17	Fibrosclerosing sarcoma	2	1
18	Liposarcoma	3	1
19	Osteosarcoma	3	2
20	Osteosarcoma	3	1
21	Osteosarcoma	3	2
22	Osteosarcoma	3	2
23	Osteosarcoma	3	2
24	Ewing's sarcoma	3	2
25	Osteosarcoma	3	2
26	Ewing's sarcoma	3	2
27	Synovial sarcoma	2	0
28	Myxofibrosarcoma	3	1
29	Pleomorphic sarcoma	3	1
30	Liposarcoma	2	2
31	Osteosarcoma	3	2

2 groupes:
 Bas grade: 1+2
 Haut grade: 3

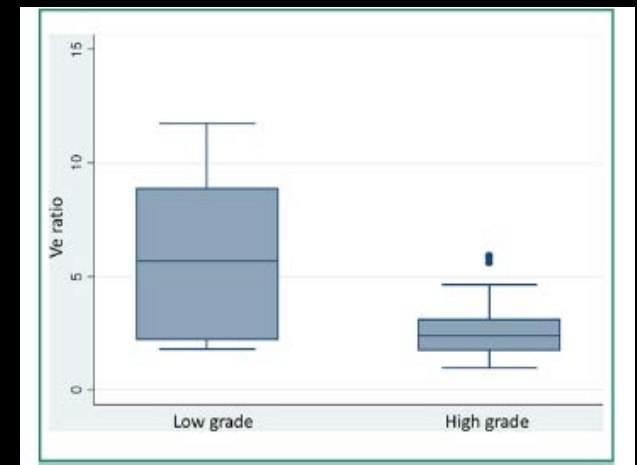
Perfusion MR imaging at 3-Tesla: Can it predict tumor grade and histologic necrosis rate of musculoskeletal sarcoma?

RESULTATS

GRADE T/ Perfusion

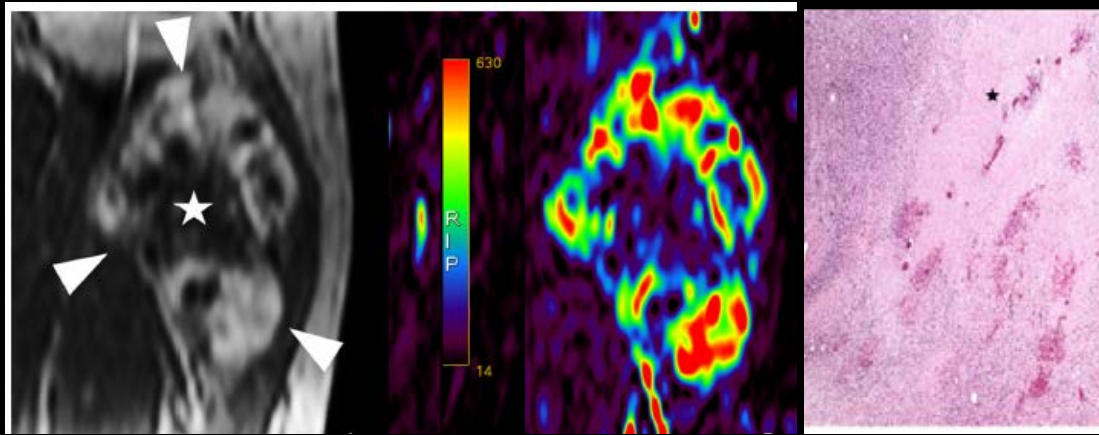
Reader 1		CER	AUC	Max slope	K^{trans}	K_{ep}	V_e
Grade	Mean low grade	4.8 ± 2.8	6.5 ± 7.0	3.6 ± 2.7	4.7 ± 2.4	1.1 ± 0.4	4.5 ± 3.4
	Mean high grade	3.4 ± 2.8	4.7 ± 7.8	3.1 ± 4.5	5.8 ± 6.3	1.8 ± 1.5	3.1 ± 1.2
	Difference	-28.3%	-26.2%	-15.8%	18.9%	36.1%	-31.4%
	P-value	0.27	0.61	0.74	0.65	0.3	0.06

Reader 2		CER	AUC	Max slope	K^{trans}	K_{ep}	V_e
Grade	Mean low grade	4.2 ± 2.4	10.2 ± 13.4	4.1 ± 3.1	6.9 ± 4.4	1.2 ± 0.7	6.1 ± 3.6
	Mean high grade	2.8 ± 1.9	5.2 ± 8.2	2.9 ± 3.4	4.3 ± 3.7	1.8 ± 2	2.8 ± 1.5
	Difference	-33.2%	-49.4%	-31.4%	-37.3%	33.6%	-54.8%
	P-value	0.13	0.25	0.37	0.14	0.45	0.02



Perfusion MR imaging at 3-Tesla: Can it predict tumor grade and histologic necrosis rate of musculoskeletal sarcoma?

RESULTATS



- 14 : index de nécrose bas
- 17: index de nécrose élevé

INI (% nécrose calculé) : différent entre les deux groupes ($p < 0.005$)
Sous estimation de 32 à 58%

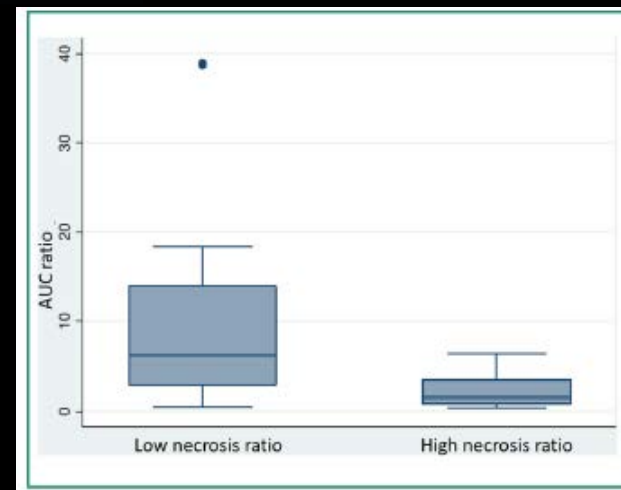
Perfusion MR imaging at 3-Tesla: Can it predict tumor grade and histologic necrosis rate of musculoskeletal sarcoma?

RESULTATS

Nécrose H / Perfusion

Reader 1		CER	AUC	Max slope	K^{trans}	K_{ep}	V_e
Necrosis rate	Mean low NR	5 ± 3.4	9 ± 10	5.1 ± 5.5	7.1 ± 6.5	2 ± 1.6	3.6 ± 2.1
	Mean high NR	2.7 ± 1.7	1.8 ± 1.9	1.7 ± 1.3	4.3 ± 4.6	1.4 ± 1.1	3.3 ± 1.9
	Difference	-45.4%	-79.8%	-67.6%	-39.8%	-29.3%	-6.4%
	P-value	0.3	0.02*	0.03*	0.2	0.19	0.74

Reader 2		CER	AUC	Max slope	K^{trans}	K_{ep}	V_e
Necrosis rate	Mean low NR	4.3 ± 2.3	11.2 ± 12.7	5.2 ± 4.2	6.3 ± 4.1	2.2 ± 2.5	4.4 ± 3.2
	Mean high NR	2.2 ± 1.2	2.2 ± 1.8	1.5 ± 0.9	3.7 ± 3.6	1.5 ± 0.9	2.8 ± 1.5
	Difference	-50.2%	-80.0%	-71.1%	-41.1%	-43.3%	-36.4%
	P-value	0.01*	0.03*	0.04*	0.08	0.2	0.1



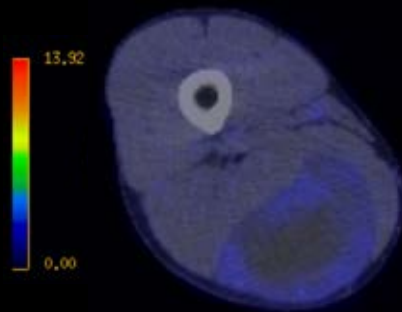
Perfusion MR imaging at 3-Tesla: Can it predict tumor grade and histologic necrosis rate of musculoskeletal sarcoma?

RESULTATS ET PERSPECTIVES:

- Paramètres semi-quantitatifs : AUC / maximum Slope – Nécrose T. histologique
Reproductibilité inter-observateur
- Le pourcentage de nécrose calculé (INI): sous estimé par rapport à la nécrose histologique, mais bon reflet de nécrose T dans le cadre d'un suivi
- Paramètres perméabilités (Kep/ Ve) – Grade T : faible association
- Biais: faible nombre, hétérogénéité série

► RATIONNEL

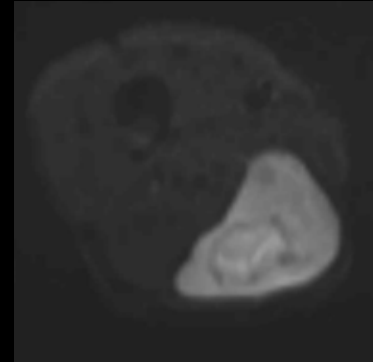
- Métastases os et tissus mous souvent antérieures aux métastases pulmonaires
- Lésions peu fixantes au TEP-scanner,
- Faible contraste au scanner par rapport aux tissus adjacents
- Séquences T2 STIR et Diffusion: extrêmement sensible



¹⁸F-FDG-PET/CT



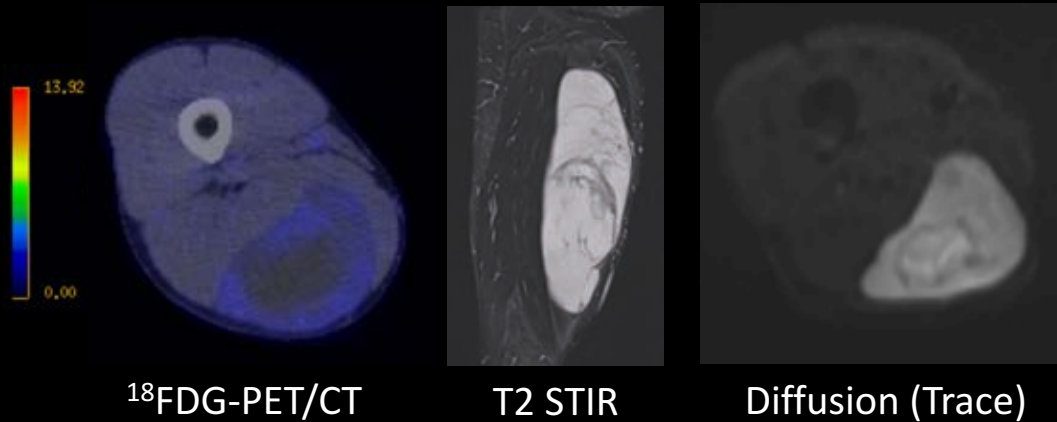
T2 STIR



Diffusion (Trace)

RATIONNEL

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- Lésions peu fixantes au TEP-scanner,
- Faible contraste au scanner par rapport aux tissus adjacents
- Séquences T2 STIR et Diffusion: extrêmement sensible



Comparaison CT vs. WB-MRI

→ significativement plus de lésions détectées avec l'IRM

METHODOLOGIE

Etude monocentrique retrospective réalisée sur 10 ans (McGill University)
33 patients

Suivi STANDARD par: $\left[\begin{array}{l} - \text{CT thoracique (/3mois – 2ans)} \\ - \text{puis RX thorax (/6mois – 5ans puis /an – 10ans)} \end{array} \right.$

WB-MRI **EN PLUS** (intervalles irréguliers – 150 examens)
Idem: CT abdominal, PET-CT

▶ **RESULTATS**

9 /33 patients ont eu une rechute métastatique
Rechute asymptomatique chez 8/9 patients

Site initial de rechute métastatique: 0/9 pulmonaire.

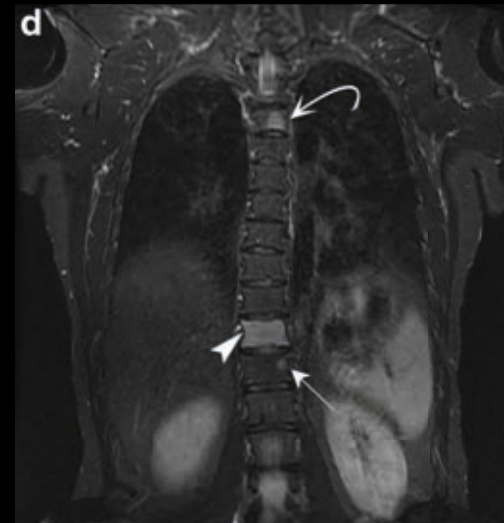
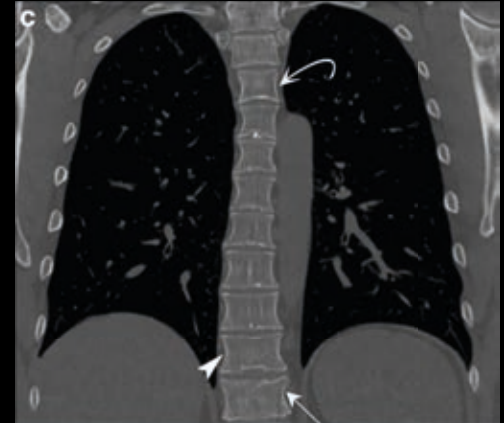
RESULTATS

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Site initial de rechute métastatique: 0/9 pulmonaire.

Le site initial diagnostiqué par:

- **WB-MRI: 7/9 patients**
7/7 patients: Métastase dans le champ de vue du scanner contemporain du WB-MRI mais occulte au CT.
- **CT thoracique: 1/9 patient**
- **CT abdominal: 1/9 patient**



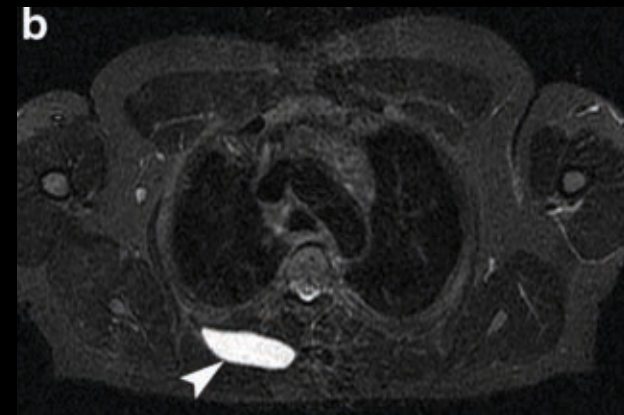
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- **CT thoracique: 1/9 patient**
- **CT abdominal: 1/9 patient**



► RELEVANCE et OUVERTURES

➔ Supériorité de WB-MRI: partagée par les radiologues experts

Manque de données comparatives CT vs. WB-MRI propres méthodologiquement

A chest spiral CT scan is mandatory for staging purposes. Regional lymph node metastases are rare, with the exception of some histologies, e.g. epithelioid sarcoma and clear cell sarcoma, for which regional assessment through CT/MRI may be added to the usual staging procedures. Likewise, an abdominal CT scan may be added for limb myxoid liposarcoma. The brain CT scan may be added for alveolar soft part sarcoma, clear cell sarcoma and angiosarcoma.

Bone scan, whole-body MRI and PET scan are optional. Cost-effectiveness studies on their incorporation into the staging procedures are required. The surgical report, or patient chart, should provide details on:

► RELEVANCE et OUVERTURES

➔ Supériorité de WB-MRI: partagée par les radiologues experts
Manque de données comparatives CT vs. WB-MRI propres méthodologiquement

➔ Impact d'une détection plus précoce des métastases par WB-MRI?
Etude cout efficacité?

► RELEVANCE et OUVERTURES

➔ Supériorité de WB-MRI: partagée par les radiologues experts
Manque de données comparatives CT vs. WB-MRI propres méthodologiquement

➔ Impact d'une détection plus précoce des métastases par WB-MRI?
Etude cout efficacité?

➔ Etudes ancillaires pour M/RC-LPS inclus dans les essais en cours et à venir:
ajout d'une WB-MRI couplée au CT lors des évaluations?

Integrated 18F–FDG PET/MRI compared to MRI alone for identification of local recurrences of soft tissue sarcomas: a comparison trial

Eur J Nucl Med Mol Imaging
DOI 10.1007/s00259-017-3736-y

Youssef Erfanian¹ · Johannes Grueneisen¹ · Julian Kirchner² · Axel Wetter¹ · Lars Erik Podleska³ · Sebastian Bauer⁴ · Thorsten Poeppel⁵ · Michael Forsting¹ · Ken Herrmann⁵ · Lale Umutlu¹

RATIONNEL

IRM: sensible mais distinction difficile entre [tissus fibro-inflammatoires récidive.

Valeur ajoutée du PET?

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Valeur ajoutée du PET?

METHODE

Etude prospective unicentrique

41 patients avec suspicion clinique de rechute locale

Acquisition PET-IRM à 3 Tesla

Gold standard: anapath et suivi rapproché en cas d'imagerie négative

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METHODE

Etude prospective unicentrique

41 patients avec suspicion clinique de rechute locale

Acquisition PET-IRM à 3 Tesla

Gold standard: anapath et suivi rapproché en cas d'imagerie négative

2 radiologues: [- Lecture IRM seule
- 1.5 mois plus tard : lecture PET-IRM

Critères de rechute: IRM morphologique, IRM diffusion, PET
+ indice de confiance du radiologue dans son diagnostic

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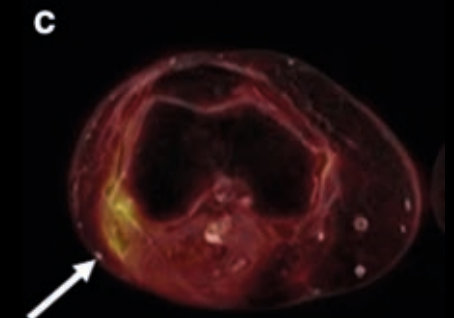
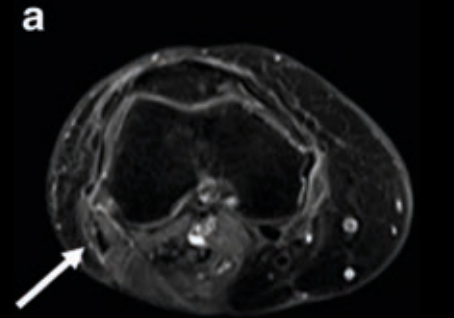
RESULTATS

27/41 rechutes locales confirmées

22/27 par IRM seule + 2 faux-positifs par IRM

26/27 par PET-IRM + 1 faux positif par PET-IRM

→ Rattrapage de 4 faux-négatifs de l'IRM par PET-IRM



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RESULTATS

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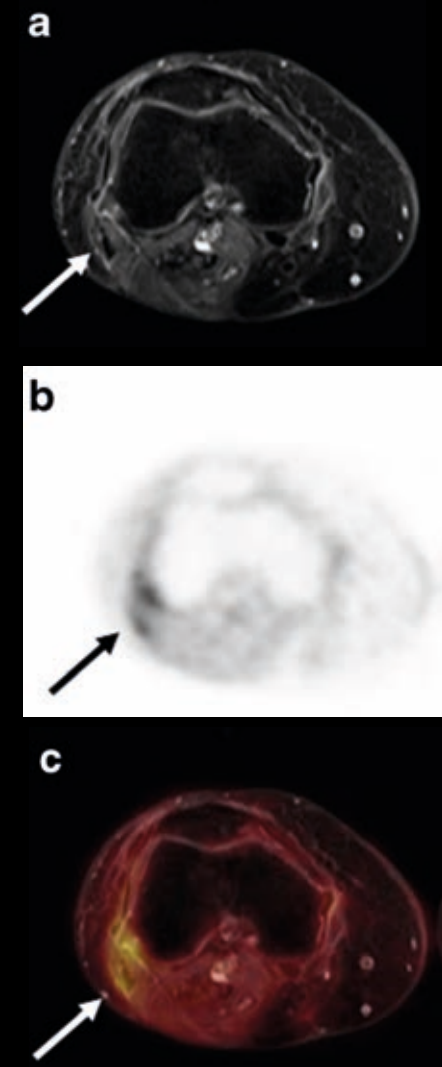
22/27 par IRM seule + 2 faux-positifs par IRM

26/27 par PET-IRM + 1 faux positif par PET-IRM

→ Rattrapage de 4 faux-négatifs de l'IRM par PET-IRM

Pas de différence significative des performances

Score de confiance plus élevé avec PET-MRI (p=0.019)



Erfanian et al. EJNMMI 2017

Table 4 Patient based statistical analysis of performance in MRI and PET/MRI

Parameters	MRI	PET/MRI
Sensitivity (95% CI)	81.5% (61.9%- 93.7%)	96.3% (81.0% -99.9%)
Specificity (95% CI)	85.7% (57.2%- 98.2%)	78.6% (49.2%-95.3%)
PPV(95% CI)	91.7% (73.0%- 98.9%)	89.7% (72.7%- 97.8%)
NPV(95% CI)	70.6% (44.0%-89.7%)	91.7% (61.5%-99.89%)
Accuracy (95% CI)	82.9% (67.9%-92.8%)	90.2% (76.9%-97.3%)

Integrated 18F-FDG PET/MRI compared to MRI alone for identification of local recurrences of soft tissue sarcomas: a comparison trial

Eur J Nucl Med Mol Imaging
DOI 10.1007/s00259-017-3736-y

Youssef Erfanian¹ · Johannes Grueneisen¹ · Julian Kirchner² · Axel Wetter¹ · Lars Erik Podleska³ · Sebastian Bauer⁴ · Thorsten Poeppel⁵ · Michael Forsting¹ · Ken Herrmann⁵ · Lale Umutlu¹

RELEVANCE et OUVERTURES

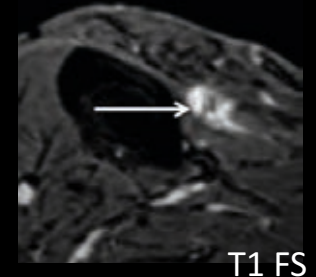
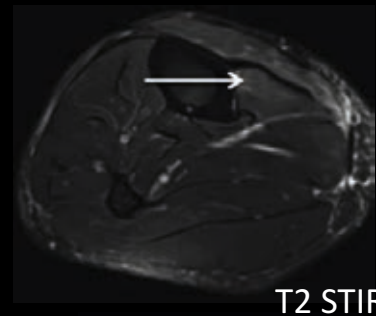
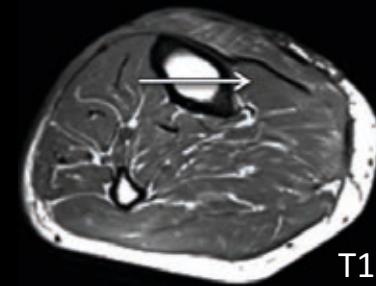
Comparaison aux performances de DCE-MRI?
Non-intégrée aux critères positifs de rechute

Stratégie?

1/ IRM + DCE-MRI

2/ PET si : $\left[\begin{array}{l} - \text{doute radiologique} \\ - \text{forte suspicion clinique} \end{array} \right.$

Avec **fusion PET avec IRM** (+ DCE-MRI)



JAMA Oncology | Review

The Potential of Radiomic-Based Phenotyping in Precision Medicine

A Review

Hugo J. W. L. Aerts, PhD

ESMO

Annals of Oncology 28: 1191–1206, 2017
doi:10.1093/annonc/mdx034
Published online 7 February 2017

REVIEW

Promises and challenges for the implementation of computational medical imaging (radiomics) in oncology

E. J. Limkin^{1,2*}, R. Sun^{1,2,3*}, L. Dercle⁴, E. I. Zacharaki⁵, C. Robert^{1,2,3}, S. Reuzé^{1,2,3}, A. Schemberg^{1,2,3}, N. Paragios^{5,6}, E. Deutsch^{1,2} & C. Fertil^{1,2*}


REVIEWS

Radiomics: the bridge between medical imaging and personalized medicine

Philippe Lambin¹, Ralph T.H. Leijenaar^{2*}, Timo M. Deist^{1*}, Jurgen Peerlings^{1,2}, Evelyn E.C. de Jong¹, Janita van Timmeren¹, Sebastian Sanduleanu¹, Ruben T.H.M. Larue¹, Aniek J.G. Even¹, Arthur Jochems¹, Yvanka van Wijk¹, Henry Woodruff¹, Johan van Soest¹, Tim Lustberg¹, Erik Roelofs^{1,3}, Wouter van Elmpt¹, Andre Dekker¹, Felix M. Mottaghy^{2,4}, Joachim E. Wildberger² and Sean Walsh¹

Radiomics: Extracting more information from medical images using advanced feature analysis

Philippe Lambin^{a,*c,f}, Emmanuel Rios-Velazquez^{a,c}, Ralph Leijenaar^{a,c}, Sara Carvalho^{a,c}, Ruud G.P.M. van Stiphout^{a,c}, Patrick Granton^{a,c}, Catharina M.L. Zegers^{a,c}, Robert Gillies^{b,e}, Ronald Boellard^{c,e}, André Dekker^{a,c}, Hugo J.W.L. Aerts^{a,d,c}



Radiology

Radiomics: Images Are More than Pictures, They Are Data¹

Robert J. Gillies, PhD
Paul E. Kinahan, PhD
Hedvig Hricak, MD, PhD, Dr(hc)

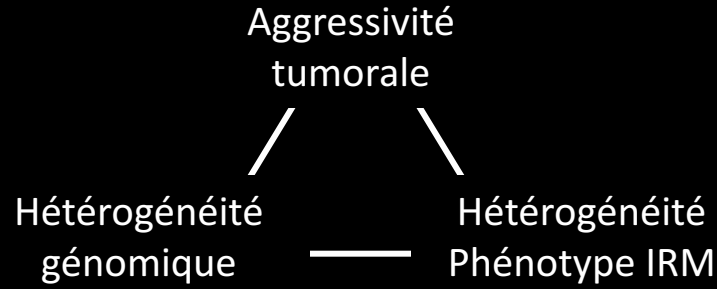
nature COMMUNICATIONS

Decoding tumour phenotype by noninvasive imaging using a quantitative radiomics approach

Hugo J.W.L. Aerts^{1,2,3,4,*}, Emmanuel Rios Velazquez^{1,2,*}, Ralph T.H. Leijenaar¹, Chintan Parmar^{1,2}, Patrick Grossmann², Sara Carvalho¹, Johan Bussink⁵, René Monshouwer⁵, Benjamin Haibe-Kains⁶, Derek Rietveld⁷, Frank Hoesbers¹, Michelle M. Rietbergen⁸, C. René Leemans⁸, Andre Dekker¹, John Quackenbush⁴, Robert J. Gillies⁹ & Philippe Lambin¹

► Définitions

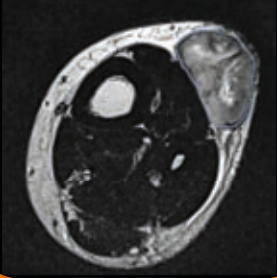
Hypothèse initiale



Quantifier l'hétérogénéité via l'imagerie à l'aide d'outils mathématiques d'analyse d'image – **Analyse de TEXTURE et de FORME**

Principe général

3D-Segmentation



Post-processing



Normalization
Denoising
Resampling

Features Extraction

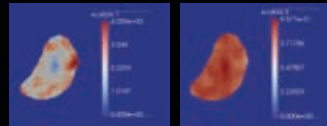
Shape



Histogram



2nd order



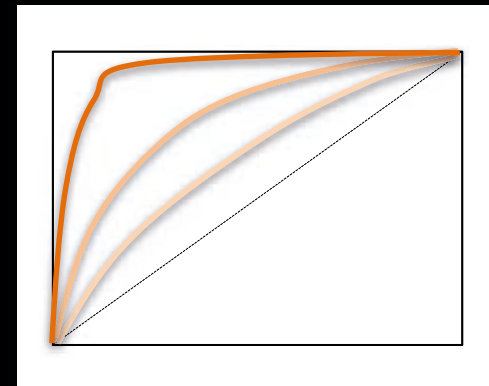
Fractal,
Wavelet ...

Réduction
Sélection des
variables

Construction de
modeles prédictifs

“classique”
Machine learning,
Réseaux de neurones

Intégration:
- Données cliniques
- Données sémantiques
- Autres “-omics”



► **Différentiation Bénin vs. Malin**

→ Juntju J et al. Machine learning study of several classifiers trained with texture analysis features to differentiate benign from malignant soft-tissue tumors in T1-MRI images. *JMRI* 2010;31:680-9

→ Thornhill et al. Differentiation of lipoma from liposarcoma on MRI using texture and shape analysis. *Acad Radiol* 2014;21:1185-1194

▶ **Différentiation Bénin vs. Malin**

▶ **Prédiction du grade**

→ Corino V et al. Radiomics analysis of soft tissue sarcomas can distinguish intermediate from high-grade lesions. JMRI 2018;47:829-840

▶ **Différentiation Bénin vs. Malin**

▶ **Prédiction du grade**

▶ **Prédiction de la réponse au traitement**

→ Tian F et al. Response assessment to neoadjuvant chemotherapy in soft tissue sarcomas: using CT texture analysis in comparison to tumor size, density and perfusion. *Abdom Imaging* 2014;40 :1705-12. (Bevacizumab + RT)

→ Hayano K et al. Texture analysis of non-contrast-enhanced computed tomography for assessing angiogenesis and survival of soft tissue sarcoma. *J Comput Assist Tomogr* 2015;39:607-12. (Bevacizumab + RT)

→ Crombé A, Perier C et al. T2-based MRI delta-radiomics can improve response prediction in soft-tissue sarcoma treated by neoadjuvant chemotherapy. ECR 2018. *In press* (AI)

▶ **Différentiation Bénin vs. Malin**

▶ **Prédiction du grade**

▶ **Prédiction de la réponse au traitement**

▶ **Prédiction de la survie et de la rechute métastatique**

→ Eary JF et al. Spatial heterogeneity in sarcoma 18F-FDG uptake as a predictor of patient outcome. J Nucl Med 2008;49:1973-1979

→ Vallières M et al. A radiomics model from joint FDG-PET and MRI texture features for the prediction of lung metastases in soft tissue sarcomas of the extremities. Phys. Med. Biol. 2015;60:5471-5496.

→ Vallières et al. Enhancement of multimodality texture-based prediction models via optimization of PET and MR image acquisition protocols: a proof of concept. Phys. Med. Biol. 2017;62:8536-5565.

PARTIE 3

Radiomique

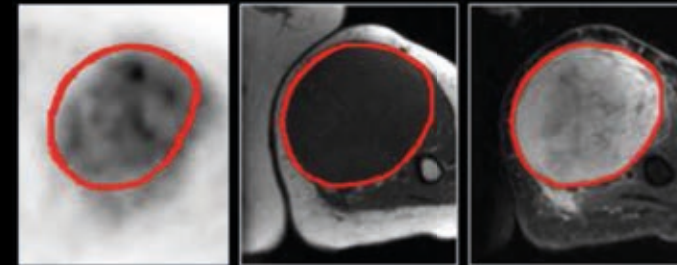
A radiomics model from joint FDG-PET and MRI texture features for the prediction of lung metastases in soft-tissue sarcomas of the extremities

M Vallières¹, C R Freeman², S R Skamene² and I El Naqa^{1,2}

METHODOLOGIE

Etude retrospective 51 patients
FDG-PET et IRM baseline (T1, T2FS)

Outcome: survenue de métastase pulmonaire (suivi >1 an)



Texture type	Reference(s)	Texture name
Global	—	Variance Skewness Kurtosis
GLCM ^a	(Haralick <i>et al</i> 1973)	Energy Contrast Correlation Homogeneity Variance Sum Average Entropy
GLRLM ^b	(Galloway 1975)	Short Run Emphasis (SRE) Long Run Emphasis (LRE) Gray-Level Non-uniformity (GLN) Run-Length Non-uniformity (RLN) Run Percentage (RP)
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	(Thibault <i>et al</i> 2009)	Gray-Level Variance (GLV) Zone-Size Variance (ZSV)
NGTDM ^d	(Amadasun and King 1989)	Coarseness Contrast Busyness Complexity Strength

PARTIE 3

Radiomique

A radiomics model from joint FDG-PET and MRI texture features for the prediction of lung metastases in soft-tissue sarcomas of the extremities

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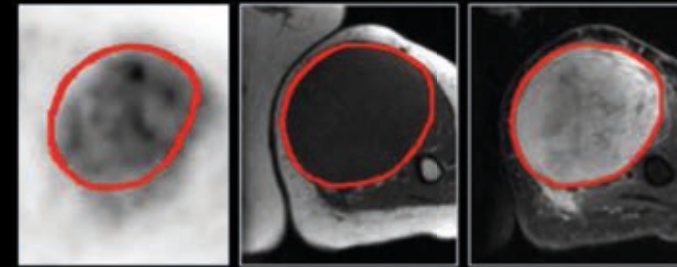
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Création de modèles multivariés

- FDG-PET seul
- IRM seule
- Fusion PET-IRM



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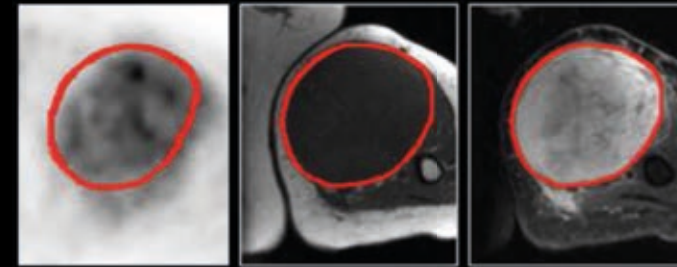
- FDG-PET seul
- IRM seule
- Fusion PET-IRM

+ Optimisation du post-traitement d'images

(pondération IRM et PET lors de la fusion des images,
taille des voxels,
filtres,

discretisation des niveaux de gris dans l'image....)

En incluant ou non l'œdème dans le contourage



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Radiomique

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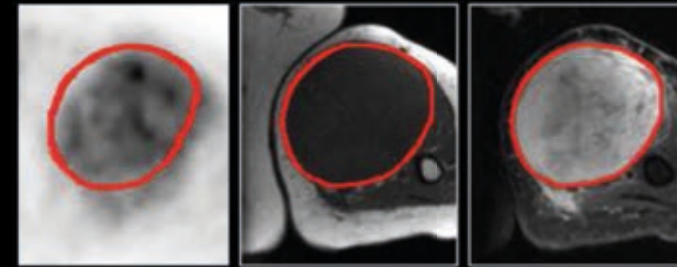
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+ Optimisation du post-traitement d'images

(pondération IRM et PET lors de la fusion des images,
taille des voxels,
filtres,
discretisation des niveaux de gris dans l'image....)

En incluant ou non l'oedeme dans le contourage

Plusieurs milliers de variables,
algorithme de réduction et sélection des features
Test de toutes les combinaisons
Sélectionner sur la base de l'AUROC et accuracy



Texture type	Reference(s)	Texture name
Global	—	Variance Skewness Kurtosis
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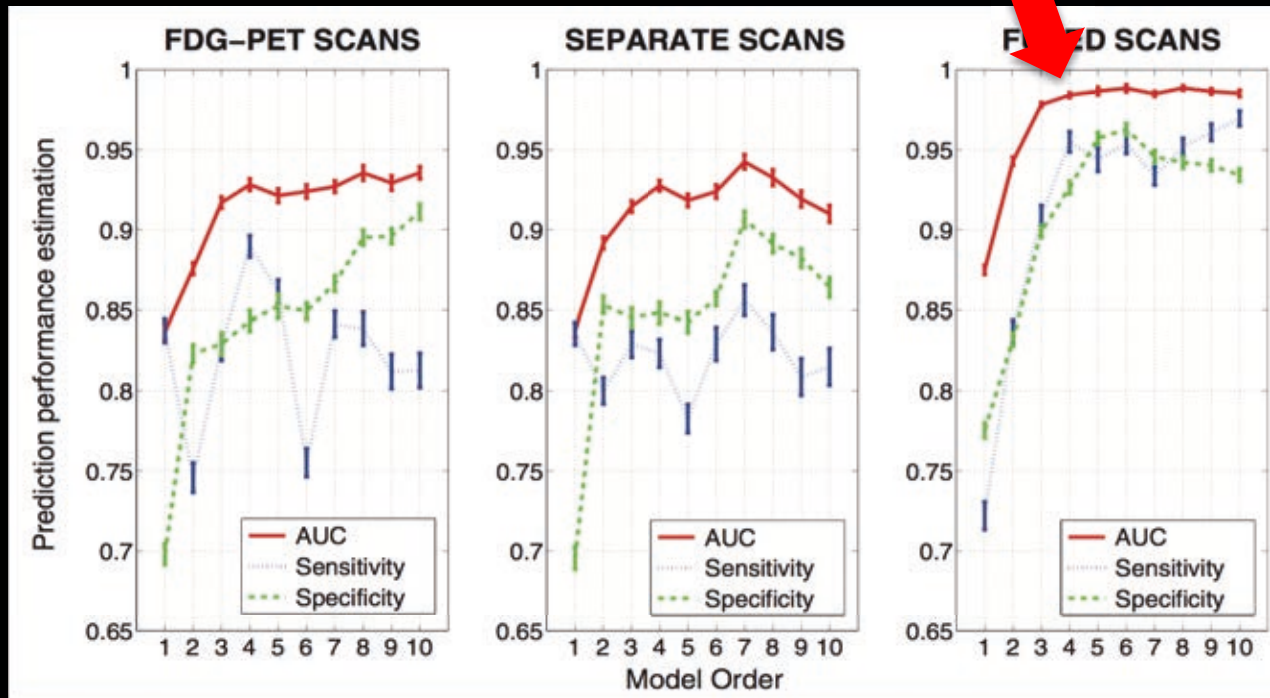
PARTIE 3

Radiomique

A radiomics model from joint FDG-PET and MRI texture features for the prediction of lung metastases in soft-tissue sarcomas of the extremities

M Vallières¹, C R Freeman², S R Skamene² and I El Naqa^{1,2}

RESULTATS



FDG-PET/T2FS(MRI Inv. = Inv., MRI weight = 3/4, R = 2, Scale = 1 mm, Quant. algo. = Equal, Ng = 8) -- GLRLM/HGRE

PET/T2FS(MRI Inv. = No Inv., MRI weight = 1/2, R = 3/2, Scale = 3 mm, Quant. algo. = Lloyd-Max, Ng = 64) -- GLSZM/SZE

FDG-PET/T1(MRI Inv. = Inv., MRI weight = 1/2, R = 1/2, Scale = in-pR, Quant. algo. = Lloyd-Max, Ng = 16) -- GLSZM/ZSV

FDG-PET/T1(MRI Inv. = Inv., MRI weight = 3/4, R = 1, Scale = 2 mm, Quant. algo. = Lloyd-Max, Ng = 8) -- GLSZM/HGZE

PARTIE 3
Radiomique

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ARTICLE “COMPAGNON”

Enhancement of multimodality texture-based prediction models via optimization of PET and MR image acquisition protocols: a proof of concept

Phys. Med. Biol. **62** (2017) 8536–8565

Martin Vallières^{1,4}, Sébastien Laberge², André Diamant¹ and Issam El Naqa^{1,3}

Amélioration du modèle en optimisant les paramètres d'acquisition
Reconstitution de différentes séquences T1 et T2 en variant les TE et TR

AUROC passant de 0.84 à 0.89 (statistiquement différent)

Magnetic Resonance Imaging–Based Grading of Cartilaginous Bone Tumors

Added Value of Quantitative Texture Analysis

Benjamin Fritz, MD,† Daniel A. Müller, MD,‡§ Reto Sutter, MD,*† Moritz C. Wurnig, MD, MSc,†§
Matthias W. Wagner, MD,†§ Christian W.A. Pfirrmann, MD, MBA,*† and Michael A. Fischer, MD*†*

Investigative Radiology • Volume 00, Number 00, Month 2018

RATIONNEL:

Evaluation des critères morphologiques IRM / Analyse de texture (TA)
pour la classification des tumeurs cartilagineuses

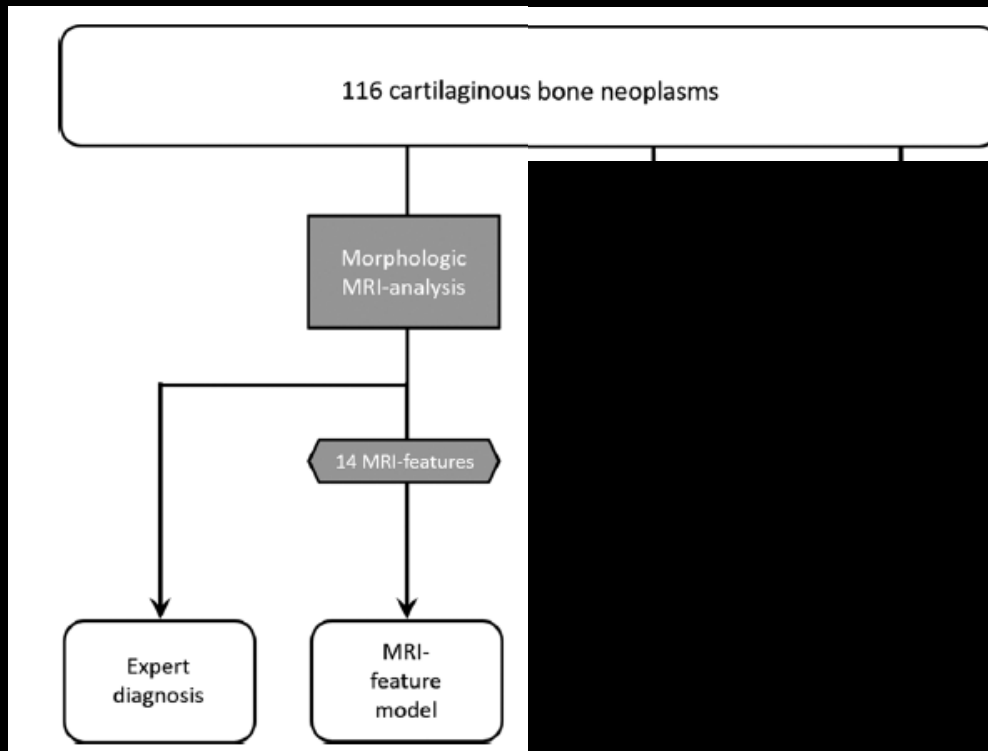
Magnetic Resonance Imaging–Based Grading of Cartilaginous Bone Tumors

Added Value of Quantitative Texture Analysis

METHODOLOGIE

Etude monocentrique rétrospective (2008-2016) :

- 116 tumeurs cartilagineuses primitives des membres [15- 88 ans]
- 37 enchondromes (suivi 5 ans si non opéré) / 63 chondrosarcomes (grade 1-3)



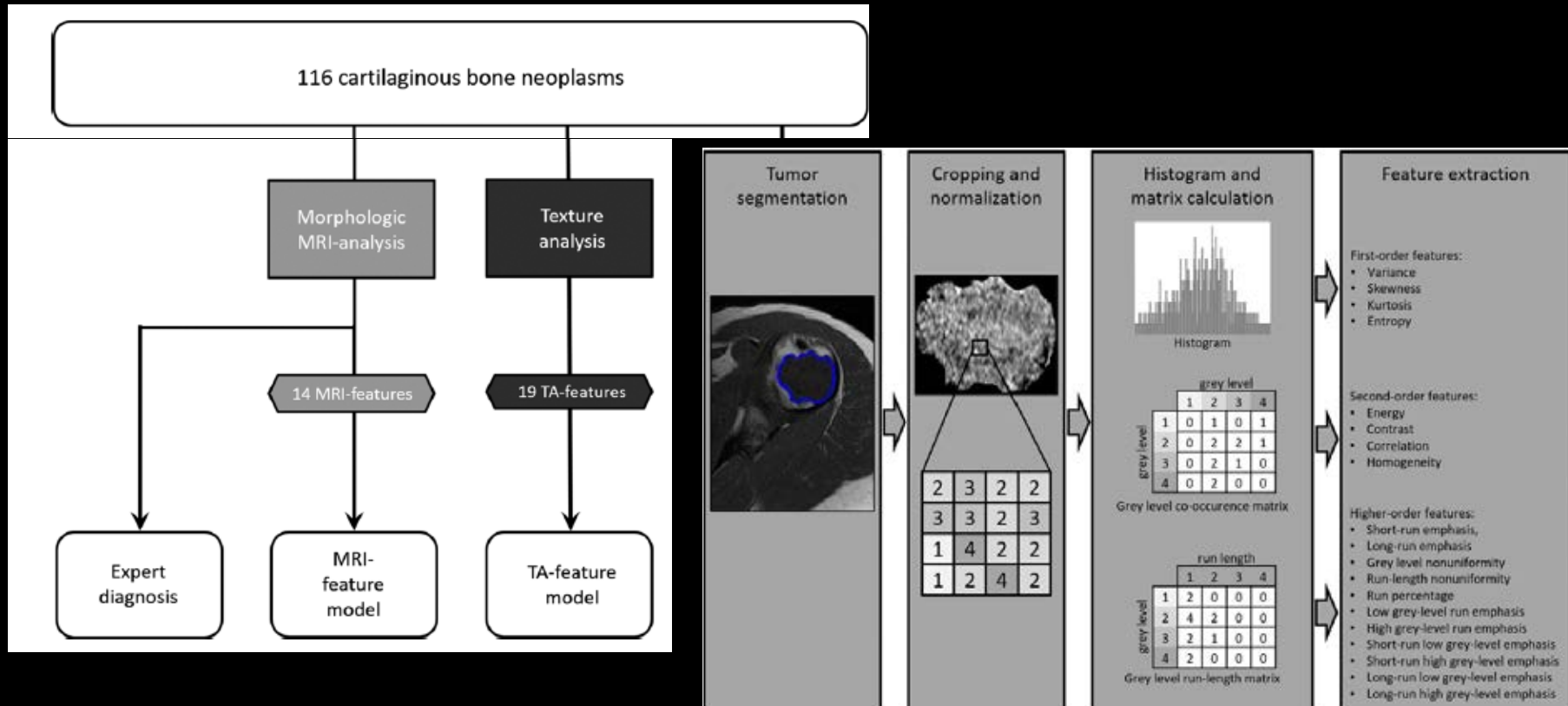
MRI Features

- 1 Cortical thickening
- 2 Cortical scalloping
- 3 Cortical destruction*†‡§||
- 4 Bone expansion
- 5 Active periostitis*§||
- 6 Reactive bone marrow edema*†‡§||
- 7 Reactive soft tissue edema *§||
- 8 Soft tissue mass*†‡§
- 9 Internal septal or ring-and-arc enhancement
- 10 Lobular outer margins
- 11 Central nonenhancing portion
- 12 Intralesional enhancing solid portion
- 13 Fat inclusion
- 14 Maximum tumor extent, cm*||

Magnetic Resonance Imaging–Based Grading of Cartilaginous Bone Tumors

Added Value of Quantitative Texture Analysis

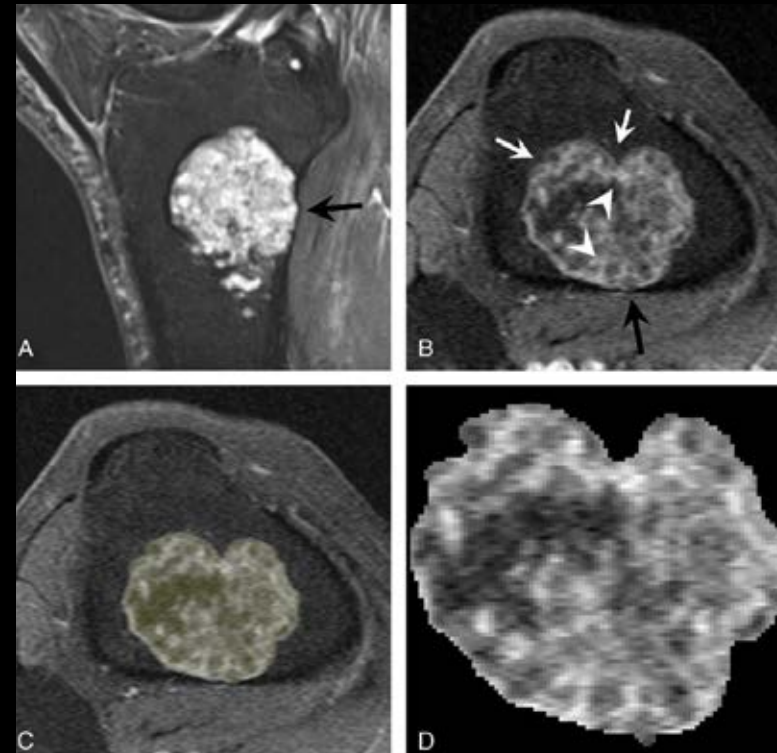
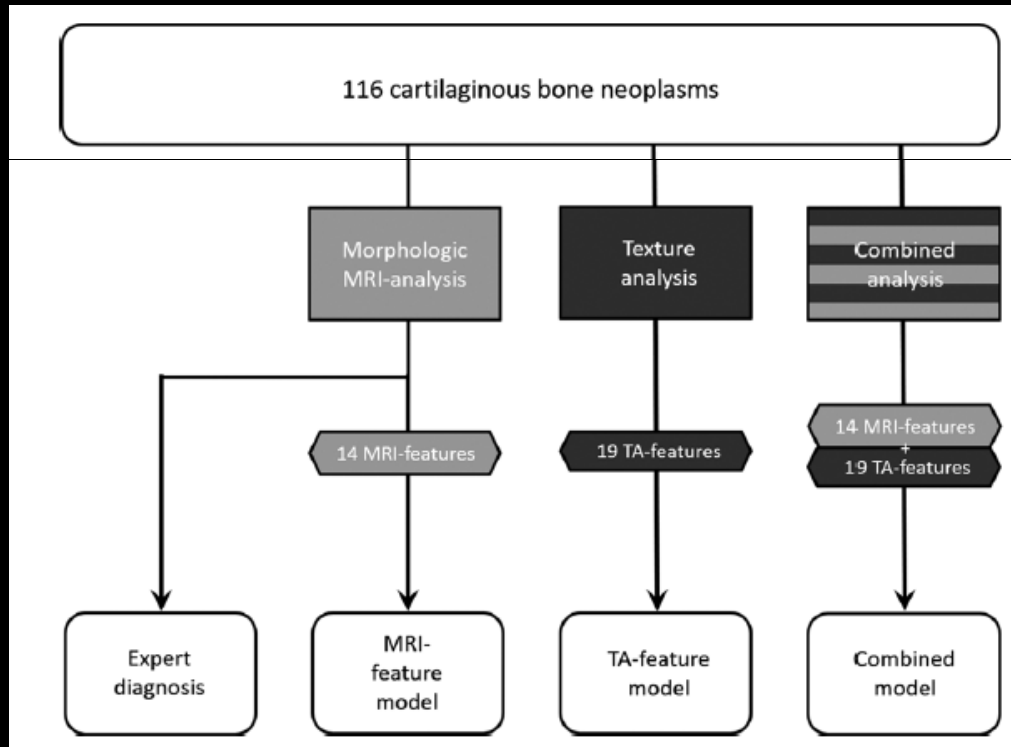
METHODOLOGIE



Magnetic Resonance Imaging–Based Grading of Cartilaginous Bone Tumors

Added Value of Quantitative Texture Analysis

METHODOLOGIE



Magnetic Resonance Imaging–Based Grading of Cartilaginous Bone Tumors

Added Value of Quantitative Texture Analysis

RESULTATS

Critères morphologique IRM

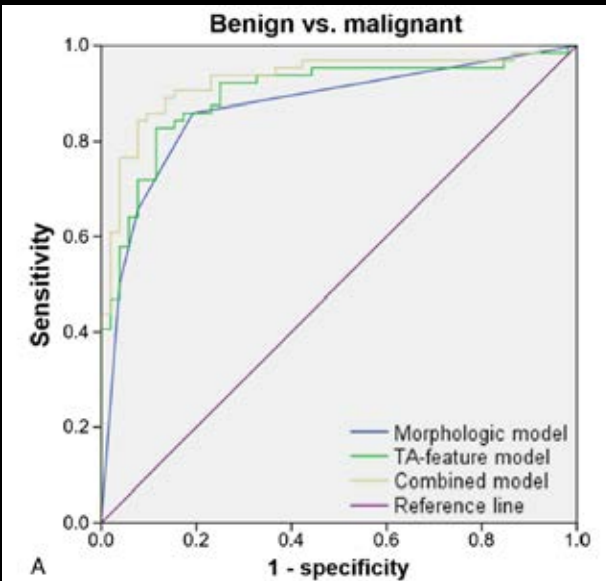
TABLE 1. Univariate Analysis of Association of MRI Features and Histological Tumor Grades

MRI Features	Benign (n = 52)	Low Grade (n = 27)	High Grade (n = 37)	Malignant (n = 64)	Benign vs Low Grade (P)	Low Grade vs High Grade (P)	Benign vs Malignant (P)	Kappa Value
1 Cortical thickening	4 (7.7%)	7 (25.9%)	3 (8.1%)	10 (15.6%)	0.039	0.081	0.256	0.193
2 Cortical scalloping	11 (21.2%)	11 (40.7%)	16 (43.2%)	27 (42.2%)	0.111	1	0.018	0.223
3 Cortical destruction*†‡§	10 (19.2%)	16 (59.3%)	32 (86.5%)	48 (75.0%)	0.001	0.019	< 0.001	0.741
4 Bone expansion	5 (9.6%)	7 (25.9%)	4 (10.8%)	11 (17.2%)	0.95	0.179	0.287	0.35
5 Active periostitis*§	7 (13.5%)	9 (33.3%)	32 (86.5%)	41 (64.1%)	0.074	< 0.001	< 0.001	0.693
6 Reactive bone marrow edema*†‡§	4 (7.7%)	12 (44.4%)	30 (81.1%)	42 (65.6%)	< 0.001	0.003	< 0.001	0.7
7 Reactive soft tissue edema *§	5 (9.6%)	7 (25.9%)	27 (73.0%)	34 (53.1%)	0.095	< 0.001	< 0.001	0.657
8 Soft tissue mass*†‡§	8 (15.4%)	15 (55.6%)	30 (81.1%)	45 (70.3%)	< 0.001	0.051	< 0.001	0.809
9 Internal septal or ring-and-arc enhancement	48 (92.3%)	21 (77.8%)	27 (73.0%)	48 (75.0%)	0.082	0.774	0.015	0.434
10 Lobular outer margins	47 (90.4%)	25 (92.6%)	26 (70.3%)	51 (79.7%)	1	0.033	0.13	0.388
11 Central nonenhancing portion	44 (84.6%)	22 (81.5%)	31 (83.8%)	53 (82.8%)	0.755	1	1	0.093
12 Intralesional enhancing solid portion	35 (67.3%)	21 (77.8%)	33 (89.2%)	54 (84.4%)	0.436	0.3	0.046	0.149
13 Fat inclusion	16 (30.8%)	2 (7.4%)	1 (2.7%)	3 (4.7%)	0.023	0.568	< 0.001	0.414
14 Maximum tumor extent, cm*	5.1 (SD 3.6)	6.2 (SD 3.6)	9.9 (SD 4.7)	8.3 (SD 4.6)	0.201	0.001	< 0.001	0.99¶

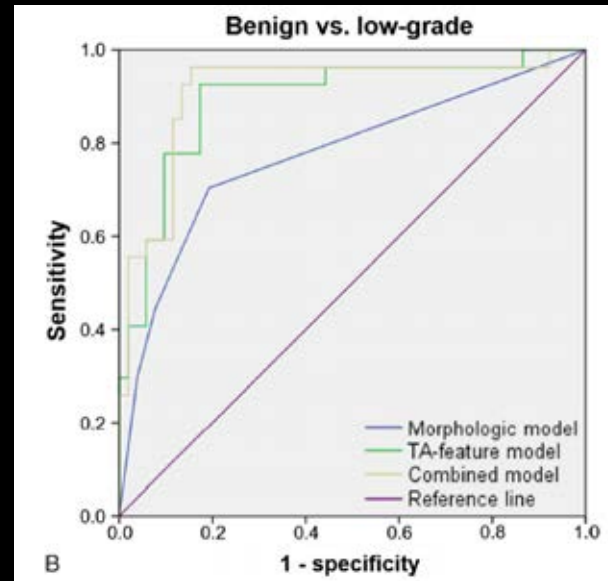
Magnetic Resonance Imaging–Based Grading of Cartilaginous Bone Tumors

Added Value of Quantitative Texture Analysis

RESULTATS



IRM: 87%
TA: 89.8%
Combinée: **92.9%**



IRM: 77.4%
TA: 89.5%
Combinée: **91.2%**

Bas grade vs haut grade

IRM: 84.8%
TA: -

→ Approche combinée

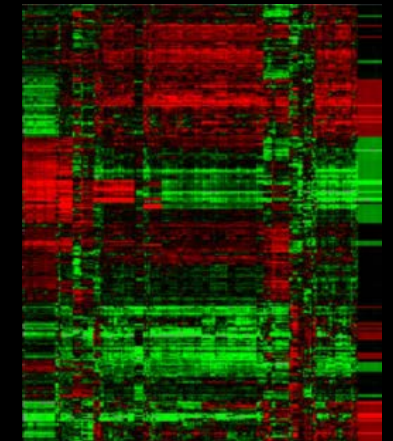
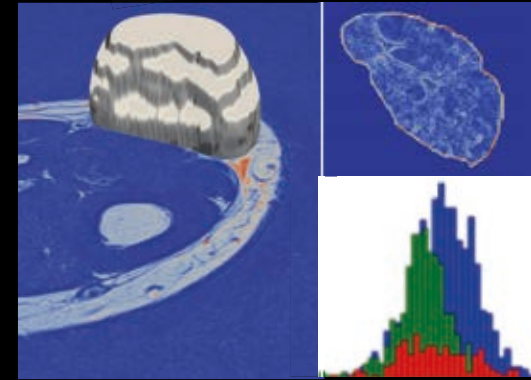
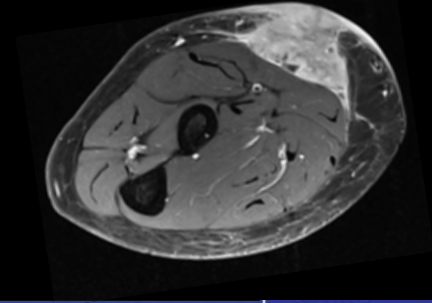
CONCLUSION

Actualité en imagerie



Axes de recherche:

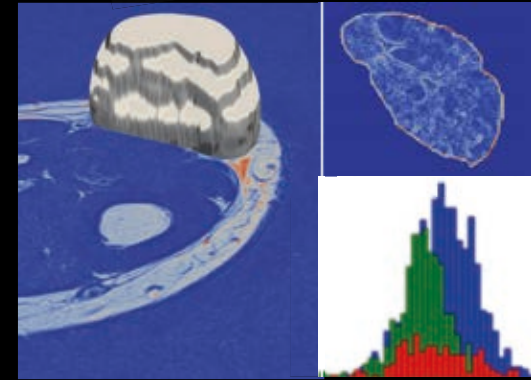
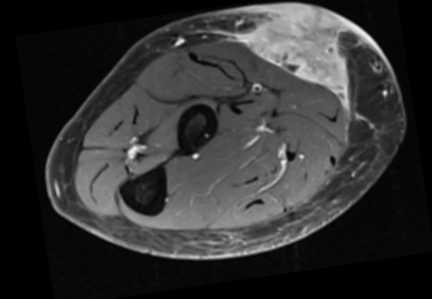
- IRM corps entier
- Analyse multimodale (PET, MRI)
- Imagerie quantitative (DCE-MRI, texture)
- Développement Machine-Learning





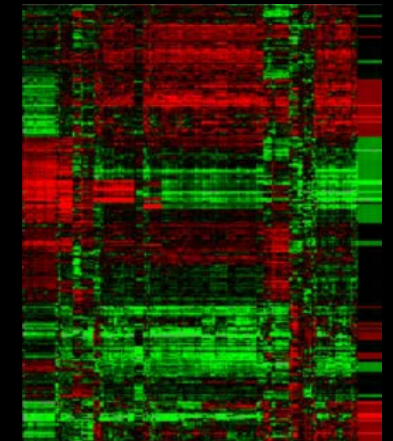
Axes de recherche:

- IRM corps entier
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Effort de standardisation des examens d'imagerie

Etudes ancillaires d'imagerie anticipées dans les essais



Merci de votre attention



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